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AUTHOR Cauley, Kathleen M.; And Others
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ABSTRACT

In 1989 the National Council of Teachers of Mathematics published the "Curriculum and Evaluation Standards for School Mathematics" (Standards). This document provides benchmark statements about specific aspects of the curriculum and about evaluation against which school divisions can judge their own specific curricula. In the fall of 1992 the Metropolitan Educational Research Consortium of the Richmond (Virginia) area undertook a study to determine the extent to which local schools were implementing the Standards. This report summarizes findings from a survey of 1,892 teachers, a survey of 108 principals, and focus group interviews with 24 selected teachers. Overall, data suggest that there is uneven implementation of the Standards and that the changes made by some teachers are by no means universal. The driving force in the classroom remains the textbook, and problem solving has not become a central focus. The area of assessment is perhaps least reflective of the Standards. It is recommended that considerable work needs to be done to implement the Standards. Meeting them requires the development of policies that clearly delineate the curriculum to be offered and provide resources to support teacher training and technology. (SLD)

THE NCTM *STANDARDS*: IMPLEMENTATION

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METROPOLITAN EDUCATIONAL RESEARCH CONSORTIUM

PO BOX 2020 • RICHMOND VA 23284-2020 • Phone: (804) 367-1332 •
FAX: (804) 367-1323 • E-MAIL: jpisapia@EDUNET.SOE.VCU.EDU

Virginia Commonwealth University and the school divisions of Chesterfield, Colonial Heights, Hanover, Henrico, Hopewell and Richmond established the **Metropolitan Educational Research Consortium** (MERC) on August 29, 1991. The founding members created **MERC** to provide timely information to help resolve educational problems identified by practicing professional educators. **MERC** membership is open to all metropolitan-type school divisions. It currently provides services to 7,000 teachers and 120,000 students. **MERC** has base funding from its membership. Its study teams are composed of University investigators and practitioners from the membership.

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- To improve educational decision-making through joint development of practice-driven research questions, design and dissemination,
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THE NCTM *STANDARDS*: IMPLEMENTATION

Prepared by:

Kathleen M. Cauley
Associate Professor
Educational Studies

John Van de Walle
Professor
Teacher Education

William T. Hoyt
MERC Fellow

Virginia Commonwealth University
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Executive Summary

THE NCTM *STANDARDS*: IMPLEMENTATION

In 1989 the National Council of Teachers of Mathematics published the *Curriculum and Evaluation Standards for School Mathematics*. The NCTM *Standards* provides benchmark statements about specific aspects of the curriculum and about evaluation against which school divisions can judge their own specific curricula. The *Standards* has been a major focus of mathematics education since 1990.

In the fall of 1992 the Metropolitan Educational Research Consortium undertook a study to determine the extent to which local schools were implementing the NCTM *Standards*. The study of the schools in the Consortium focused on the broad themes of the *Standards* document: mathematics as problem-solving, mathematics as communication, mathematics as reasoning, and mathematical communication. To teach with these four standards in mind is to teach in a *Standards*-oriented manner. This report summarizes the findings of three data sources collected from elementary, middle, and secondary school teachers and principals in the MERC school divisions: a survey of teachers, a survey of principals, and focus group interviews of selected teachers. The questions and discussions explore awareness of the *Standards*, classroom practices, and aids and obstacles to implementation.

FINDINGS

Awareness and Change

Overall the data suggests that there is an unevenness in the level of implementation. Some teachers have made changes, but many have not. However, even within those who have changed, change is not uniform, nor at a level indicative of full implementation. With a recognition of this unevenness, there are some areas where progress can be reported.

Classroom Practice

At the elementary and middle grades, teachers report use of cooperative groups, an increased use of manipulatives and computers, and there is some evidence of discussion and interaction in the classroom. The greatest areas of strength at the secondary level are mathematics as reasoning, cooperative group work, and the use of calculators.

When looking at the frequency with which most any strategy is used, it is difficult to feel complacent about the data in any given area. Clearly, there remains a lot of work to be done before we can say teachers are actually implementing the *Standards*.

While problem-solving is reportedly done by all teachers, the evidence does not support the use of problem-solving as a global approach to mathematics or as a pervading theme. Nonstandard and project-type problems are infrequently used. The driving force in the classroom remains the textbook.

The area of assessment is perhaps least reflective of the *Standards* than any other area. There is little evidence of alternative forms of assessment, portfolios, or journals. Teachers made almost no distinctions between the use of assessment for diagnostic purposes and for grading. Traditional end-of-chapter and standardized tests remain the most common forms of assessment

Aids and Obstacles

There are two factors that appear to be correlated with a movement toward a *Standards*-like classroom: (1) The support of the administration, especially at the principal level. (2) The initiative of individual teachers to take advantage of opportunities and to be self-starters. In the case of the latter, it is not clear what causes these personal characteristics.

Other factors that influence implementation of change are time (for planning, for inservice and professional growth opportunities), the pressures of standardized testing, quality inservice (or lack of same), and the availability of resources (especially in the area of technology). Teachers at the upper levels note the difficulties of working with students of low abilities as a significant obstacle.

RECOMMENDATIONS

The findings for this study generally corroborate those of the NCTM pilot study indicating that considerable work needs to be done to implement the *Standards*. District policy statements should articulate a vision of mathematics curriculum reform and revised criteria for mathematics curriculum design. Teachers need support, direction, and in-depth training.

Curriculum

At the elementary level there needs to be less emphasis on paper and pencil, rule driven computational skills and more use of mental processing and problem-solving techniques using calculators and manipulatives. At the middle school level, number sense and

problem-solving should be expanded through open-ended exploration, projects, and group work with the text used only as a resource. The curriculum should be broadened to include measurement, statistics and probability. At the secondary level, the *Standards* call for a core curriculum in which all students have access to algebra, geometry,

probability, statistics and discrete mathematics. It was not clear from the study that such a broad curricular change had been implemented. An increased and more integrated use of computers and calculators in all courses at all levels is also needed.

Assessment

Perhaps the area found most seriously lacking was assessment. In order for a *Standards*-like curriculum to be integrated, both classroom assessment practices and standardized testing must change accordingly. This is not yet the case. Assessment practices must be in alignment with the objectives of the *Standards* and must become an integral component of instruction. Teachers will need considerable assistance in quality assessment practices. Standardized testing by school divisions must also be reflective of the *Standards* in order to prevent a conflicting message from being sent to teachers and to parents.

Policy

Meeting the NCTM *Standards* depends on the development of policies that clearly delineate the curriculum to be delivered and provide the resources to support teacher training, professional growth, curricular development, assessment techniques, and the technology to implement them.

THE NCTM *STANDARDS*: IMPLEMENTATION

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Preface

In November, 1992, the Metropolitan Educational Research Consortium (MERC) Policy and Planning Council approved a proposal to study the implementation of the NCTM *Standards*. The study builds on previous MERC work in the area of mathematics; particularly the analytic and interpretive review of the National Assessment of Educational Progress Results of 1990. It also lays the foundation for 1) MERC's continuing search for information to improve mathematics teaching and learning, and 2) school division efforts to provide appropriate curricula and staff development opportunities for their teachers.

The research agenda sought answers to the following questions:

1. What is the level of awareness of teachers about the NCTM *Standards*?
2. What is the level of implementation of the NCTM *Standards* in Consortium classrooms? How do the classroom practices of teachers who perceive themselves as implementing the *Standards* differ from those of other teachers?
3. What aids have helped teachers in making these changes?
4. What components are seen as hindering progress toward these changes?

A study group was formed from MERC's membership to guide the research and dissemination activities. The study group included Helen Edens from Chesterfield County Public Schools; Beverly Cook from Colonial Heights City Public Schools; James Bagby, Vandi Hodges, and Rosa Tapscott from Hanover County Public Schools; Steven Lapinski from Henrico County Public Schools; Linda Hyslop from Hopewell City Public Schools; Linda Weber from Powhatan County Public Schools; and Jacqueline Joyner from Richmond City Public Schools.

A research team was appointed which included Kathleen Cauley and John Van de Walle as the co-principal investigators and William Hoyt, MERC Research Fellow to work with the Study Group and conduct the research. Susan Goins assisted the team and study group in meeting arrangements and document preparation.

John Pisapia, Director
Metropolitan Educational Research Consortium

THE NCTM *STANDARDS*: IMPLEMENTATION

The purpose of this study was to identify the progress and obstacles encountered by schools and teachers who have attempted implementation of the National Council for Teachers of Mathematics (NCTM) *Curriculum and Evaluation Standards for School Mathematics* and the *Professional Standards for Teaching Mathematics*. The report summarizes the findings from three data sources: a survey of mathematics teachers, a survey of principals, and focus group interviews with selected teachers. The survey of teachers within the Consortium was to determine their awareness of the *Standards*, the extent to which they currently teach in ways that are consistent with the *Standards*, and their perspective of aids and obstacles when implementing the *Standards*. The principal survey was to determine principals' awareness of the *Standards* and their perspective of the aids and obstacles in implementing them. The focus group interviews were conducted with teachers who expressed knowledge of the *Standards* and were rated as either s high or low implementation teachers. Tne purpose was to obtain more in-depth information about their success at implementation and perceived aids and obstacles.

BACKGROUND INFORMATION

Calls for change in mathematics education have been growing in number and intensity over the past 15 years when the education community began to revolt against the public cry for "back to basics." That movement was influential during the eighties in directing parent attention to the lowest level of mathematics skills, namely computation and mastery of procedural knowledge. In 1977, the National Council of Supervisors of Mathematics issued its list of Ten Basic Skills in which problem-solving enjoyed the number one position. The following year, the NCTM published *An Agenda for Action* that outlined changes in curriculum and evaluation procedures as goals for the decade of the eighties. These documents had impact largely in terms of shifting the focus from the lower level skills of arithmetic to problem-solving and higher-order thinking processes.

The decade of the eighties began an almost universal acceptance on the part of the American public of problem-solving as a truly important part of mathematics education. No other single subject has so dominated the research and publication agenda of mathematics education as has problem-solving over the last 10 years. However, while more problem-solving has clearly entered our public school curriculum, studies and reports of the state of mathematics education in this country have sounded serious warnings that all is not well.

Early in 1987, *The Underachieving Curriculum: Assessing U.S. School Mathematics from an International Perspective*, presented hard data that clearly showed the nation to be seriously behind most industrialized countries in all aspects of mathematics. The data behind that report were collected in 1981-1982, but more recent comparisons of the U.S. with other countries have failed to change the view that the U.S. is far from number one among countries and in fact, is nearly last in the area of mathematics. In June 1988, *The Mathematics Report Card* was released providing trends in U.S. performance-based on the past four NAEP studies. These data were less than promising. They clearly demonstrated the effects of our preoccupation with computation and our neglect of even the most simple reasoning skills.

In 1988, a series of reports began to direct attention to the future and provide new direction for mathematics education. *Everybody Counts* provided a clear picture of the ills of mathematics education as well as prescribing areas in need of change. The most important booklet from the Mathematical Sciences Education Board (MSEB) called for change in the way we view the nature of mathematics, changes in the teaching of mathematics, increased use of technology especially calculators, as well as fundamental changes in the curriculum. Mathematics is described by this well-received document as a "science of pattern and order." Real mathematics, according to *Everybody Counts*, must be made accessible to all students, not just an elect few. A curriculum that uses computational skill to filter out the vast majority of students from participation in real mathematics is seen as unacceptable.

THE NCTM *STANDARDS*

In the same year that *Everybody Counts* was released, and after a full year of gathering input based on a draft version, NCTM published its now much heralded *Curriculum and Evaluation Standards for School Mathematics*. This comprehensive document has received virtual unanimous acceptance as a guide for curriculum and evaluation reform movements throughout the country. Stopping short of an actual curriculum, the *Standards* provides benchmark statements about specific aspects of the curriculum and about evaluation against which school divisions can judge their own specific curricula. The *Standards* has been the major focus of mathematics education for the past three years, successfully articulating the more general call for reform found in *Everybody Counts*.

The *Standards* not only focused thinking on such aspects of mathematics as number sense, estimation and mental computation, and problem-solving, but also suggested new goals for students that have quickly become guiding principles for curriculum reform: Students will 1) Learn to value mathematics, 2) Become confident in their ability to do mathematics, 3) Become mathematical problem-solvers, 4) Learn to communicate mathematically, and 5) Learn to reason mathematically.

Perhaps more important than the five goals for students are the first four standards in each of the three grade level sections of the document (K-4, 5-8, 9-12). Here the *Standards* speaks clearly to the nature of mathematics in describing standards for:

1. Mathematics as problem-solving.
2. Mathematics as communication.
3. Mathematics as reasoning.
4. Mathematical connections.

These four standards represent over-arching themes for the mathematics curriculum. They can be applied to nearly every area and every lesson. To teach with these four standards clearly in mind is to teach in a *Standards*-oriented manner.

MATHEMATICS AS PROBLEM-SOLVING

According to the *Standards*, "problem-solving should be the central focus of the mathematics curriculum." This means much more than learning to solve word problems. Rather, mathematics *as* problem-solving means that problem-solving is a part of all real mathematical activity. The standard speaks to learning a variety of general problem-solving strategies such as making guess-and-check or looking for a pattern. It talks about being able to formulate problems and assess results. It speaks about confidence in solving problems. Problem-solving is a way of thinking and reasoning that is used in the learning and the doing of all mathematics.

MATHEMATICS AS COMMUNICATION

The communication standards at each level point to the importance of being able to talk about, describe, and explain mathematical ideas. Symbolism in mathematics along with things such as charts and graphs should become ways of expressing mathematical ideas to others. This means that students should learn not only to interpret the language of mathematics but to use that language themselves. Learning to communicate in mathematics makes accessible the world of mathematics beyond the classroom. It also fosters interaction and exploration of ideas within the classroom as students learn in an active, verbal environment.

MATHEMATICS AS REASONING

To reason logically is as integral to mathematics as problem-solving. In the past, logical reasoning was relegated to the tenth-grade geometry class. The *Standards* tells us that reasoning should be a part of mathematical activity from kindergarten on. To observe and extend a pattern, to defend a result, or to decide if an answer is correct are all activities that involve logical reasoning. When reasoning is part of all mathematics, students learn that mathematics is not a collection of arbitrary rules but a system that makes sense and can be figured out.

MATHEMATICAL CONNECTIONS

The theme of connections is really three-fold. First, the standard refers to connections within and among mathematical ideas. Addition and subtraction are intimately related. Fractional parts of a whole are connected to concepts of decimals and percents.

Second, the symbols and procedures of mathematics should be clearly connected to the conceptual knowledge that the symbolism represents. Rules such as "invert the divisor and multiply" should never be learned in the absence of well developed supporting concepts.

Third, mathematics should frequently be integrated with other discipline areas, and real applications of mathematics in the real world should be explored. Children should see that mathematics plays a significant role in art, science, and social studies. Mathematics should be viewed as a meaningful and relevant discipline, in terms of both how it is done and how it is used.

RATIONALE FOR THE STUDY

The *Standards* documents have been the focus of mathematics education for the last three years. They were developed to address the national crisis in mathematics education by changing mathematics curriculum, instruction, and assessment to promote mathematical reasoning, problem-solving and communication.

Through inservice, lead teacher projects, curriculum reform, and other means, the MERC school divisions have been making initial efforts at reform. Many area teachers are involved with professional organizations and have been encouraged to make changes due to their involvement in that way. However, the *Standards* requires radical change in how most teachers approach mathematics. It is essential that school divisions obtain an accurate view of where they are presently situated in this early stage of reform so that future plans and initiatives can be well designed.

It is also important that schools create support systems - at grade level, building and division level - that encourage and promote the use of new approaches and revised curriculum. In designing such support it is important to be aware of those factors that teachers perceive to be an aid to their reform as well as those they perceive as obstacles.

This project provides descriptive data on how teachers are responding to the challenge of reform. It describes not only the practices of mathematics education at the elementary, middle and secondary levels, but also identifies those influences on teachers that they view as either aids or obstacles to reform. This information will not only provide benchmark data on which progress toward implementation can be gauged, but also guidance for significant change in mathematics education in the schools.

RESEARCH QUESTIONS

1. What is the level of awareness of teachers about the NCTM *Standards*?
2. What is the level of implementation of the NCTM *Standards* in Consortium classrooms? How do the classroom practices of teachers who perceive themselves as implementing the *Standards* differ from those of other teachers?
3. What aids have helped teachers make these changes?
4. What components are seen as hindering progress toward these changes?

METHODOLOGY

The survey team collected data from three sources: objective responses by elementary, middle, and secondary school teachers (the Teacher Survey), objective responses from elementary, middle, and secondary school principals (the Principal Survey), and focus group discussions with a small number of teachers who reported awareness of the *Standards*. The Teacher Survey was piloted with teachers in one school division within the Consortium, and was revised based on these teacher's responses and comments prior to distribution to teachers in the other six MERC school divisions. The survey included items to determine teachers' awareness of the *Standards*, the frequency of use

of various classroom practices, and their perceptions of aids and obstacles to implementation. Responses were received from a total of 1,892 teachers, with 55% of those surveyed responding.

The Principal Survey was adapted from a subset of Teacher Survey items, and was distributed along with the Teacher Survey. Principals reported on their perceptions of teachers' awareness of the *Standards*, and of the types of changes being made by teachers in their schools, as well as their perceptions of the aids and obstacles to implementation of the *Standards* at their schools. Responses were received from 108 principals, with 59% of those surveyed responding.

The focus groups were comprised of 24 teachers from a pool of 101 teachers who reported on the Teacher Survey that they were aware of the *Standards* and who volunteered to participate in the group discussions. Only teachers who scored at the extremes of a "*Standards* implementation" index (based on their survey responses) were invited to participate. This index included 9 critical items considered to differentiate between teachers who were and were not following the recommendations of the *Standards* in their classrooms, and allowed us to compare the perceptions of "high" and "low" implementation teachers regarding aids and obstacles to making use of the *Standards* in the classroom.

OVERVIEW OF FINDINGS

1. The majority of teachers and their principals are aware of the *NCTM Curriculum and Evaluation Standards* and are in agreement with them.

2. Approximately 21% of elementary and 53% of middle and secondary teachers report that they are implementing the *Standards*. The degree of implementation, however, is relatively low. This low degree of implementation is reasonable given that the *Standards* are a relatively recent development and that implementation

requires a reconceptualization of mathematics teaching and assessment. Evidence of the low level of implementation is indicated by the following points.

2a. Teachers at all grade levels rely too heavily on non*Standards* oriented textbooks and the problems in them. Instead, the *Standards* recommend that more emphasis be given to student generated problems, "real-life" problems, and nonroutine problems.

2b. The majority of teachers do not use teaching strategies recommended in the *Standards* on a weekly basis. Evidence suggests that a number of strategies, such as cooperative group work or student justification of answers to problems are beginning to be used 2-3 times a month.

2c. The curriculum at the elementary and middle levels in contrast to the *Standards*, continues to emphasize computation. Areas such as statistics and probability should be emphasized somewhat more.

2d. Technology, particularly computers and calculators, is underutilized at all grade levels. Teachers in the focus groups report frustration at the unavailability of appropriate calculators, computers and software. Manipulatives are not being used and/or are not readily available, especially at the middle and secondary levels.

2e. Teachers who report implementing the *Standards* show a somewhat higher frequency of use of most recommended teaching strategies than the unchanged teachers.

2f. Elementary and middle teachers who are making changes in their teaching seem to implement the connections and reasoning theme of the *Standards* more readily than problem-solving or communications themes.

2g. Across grade levels, writing about mathematical ideas is a weakness, both as a teaching strategy and as an assessment strategy.

2h. Virtually no attempt has been made to implement recommendations for student assessment. Both the survey and the focus groups indicate that the majority of teachers do not appear to use alternative assessment techniques. The majority of teachers do not appear to distinguish between

assessment for diagnosis of student understanding and assessment for grading.

3. Administrative support is viewed as a critical aid to implementation. Aids to implementation that teachers find helpful include notification of workshops and conferences, availability of grant money, maintenance of a library of instructional materials.

4. The "lead teacher" initiative was viewed as an important aid to implementation by both teachers and principals at the elementary and middle grades.

5. The focus group interviews suggest that the teachers who are implementing the *Standards* are often "self-starters" who find and take advantage of the supports they need rather than waiting for input from their school division.

6. Aids to implementation not currently available but considered helpful by teachers at all grade levels are: opportunities to observe one another's classes, opportunities to exchange ideas with other teachers, and meetings with teachers at other grade levels to coordinate implementation. Overall, teachers feel that they need time to develop materials, rethink the curriculum, and meet with other teachers.

7. Teachers who have begun to implement the *Standards* cite specifically focused inservice opportunities as essential for effective implementation. Furthermore, teachers who have not changed view their own lack of knowledge and training as an obstacle to implementation. Practical inservice activities are those that clearly address classroom needs or that "show how" rather than "tell how".

8. The teacher survey, principal survey, and focus group interviews all suggested that current curriculum objectives and standardized testing programs are obstacles

to implementation, particularly at the middle and secondary levels. This is a reasonable assessment since neither emphasizes many of the themes of the *Standards*. Teachers cannot effectively teach to two sets of objectives.

DISCUSSION

AWARENESS

The vast majority of teachers at all grade levels reported that they have access to either a copy of the *Standards* or to materials describing the *Standards*. Teachers' reported level of awareness differs by grade level, however, with 44% of elementary teachers describing themselves as "well aware" of the *Standards*, as compared with 82% of middle school teachers and 83% of secondary school teachers.

Awareness of the *Standards* does not guarantee efforts at implementation, however. Of the teaches describing themselves as well aware, less than half at the elementary level, and less than two-thirds at the middle and secondary school levels, reported that they have changed their teaching practices as a result of this awareness.

The focus group data suggest that the elementary teachers who have made real changes appear to be the group most knowledgeable of the *Standards*. At the upper levels, a true understanding of the spirit of the *Standards* is less evident.

CLASSROOM PRACTICES

The Teacher Survey included items concerning teaching strategies reflecting each of the four themes of the *Standards*. The data allow us to describe the extent to which teachers in the MERC schools are implementing these themes.

In the area of **mathematics as problem-solving,** a majority of teachers at all grade levels reported use of cooperative group problem-solving at least 2-3 times a month. There is evidence of encouraging students to move away from rote responding and instead verifying and interpreting their answers with respect to the original problem.

Other problem-solving strategies appear to be employed only on an infrequent basis (less than twice a month) by the vast majority of teachers. These include providing opportunities for students to work on more complex, open-ended "project" problems, to formulate their own mathematics problems based on everyday situations, and to use computers in the development of problem-solving strategies. Although computers appear to be more actively used for problem-solving at the elementary level, more than one third of all middle and secondary school teachers reported that their students never have the opportunity to use computers for problem-solving.

The use of strategies related to **mathematics as communication** appears to be fairly uniform across grade levels.

Most teachers report providing opportunities for students to discuss mathematical ideas or to relate models, pictures or diagrams to mathematical ideas in their classrooms at least twice a month. The frequency with which students are asked to write about mathematical ideas appears to be lower, however. At each grade level, one third to one half of all teachers report that their students never are asked to write about mathematical ideas. Likewise, students are rarely encouraged to formulate definitions and/or express generalizations of mathematical principles.

Teachers report active use of teaching strategies related to **mathematics as reasoning**. Students at all three grade levels are encouraged to justify their answers to mathematical problems, and to think about "whys" as well as "hows" when reporting on mathematical investigations.

Teachers also reported use of strategies for exploring **mathematical connections**. Working with multiple representations of a single concept, applying mathematical reasoning to real life problems, and making meaningful connections between different areas of the mathematics curriculum were all reported as being done at least twice a month by a majority of teachers responding to the survey.

Mathematical connections are reportedly somewhat less emphasized at the secondary school level, and this is particularly true of connections between mathematics and other subject areas--60% of elementary teachers report this as a frequent area of exploration, as compared with 40% of middle school teachers and only 25% of secondary school teachers.

Based on teachers' perceptions of their classroom practices, it appears that strategies related to mathematical reasoning and connections are relatively well represented in the classroom, whereas strategies found under the heading of problem-solving and communication are used less frequently.

In a cautious attempt to summarize these data, Table 1 presents an overview of the responses to items categorized under each theme. The numbers in this table were derived by averaging frequency data - not an orthodox procedure for aggregating this kind of data. Note, for example, that important and less important items are weighted equally. The table is only intended to give a "bird's eye" view of responding teachers' reported use of strategies related to each theme (overall score). It also shows the degree to which teachers who perceive themselves as changed have moved in the directions recommended by the *Standards* (comparison between "changed" and "unchanged" groups).

Table 1

Average Percent of Teachers Reporting Use of

Teaching Strategies Reflecting Themes of the NCTM Standards*

Theme (# of Items)	Grade Level	Overall	Changed	Unchanged
Problem-solving (11)	Elementary	41	51	38
	Middle	35	41	28
	Secondary	33	39	26
Communication (7)	Elementary	36	45	33
	Middle	37	44	30
	Secondary	38	44	28
Reasoning (3)	Elementary	67	79	64
	Middle	73	81	64
	Secondary	81	88	72
Connections (5)	Elementary	61	73	59
	Middle	53	59	47
	Secondary	41	49	31

* 2 or more times a month

DIFFERENTIATION OF CLASSROOM PRACTICES

It is useful to look specifically at those teachers who perceive themselves as changed as compared to the others. Such a contrast better describes how concentrated the global changes are and how well and in what specific areas motivated and informed teachers are actually implementing *Standards*-like practices. It is worth noting that this is not longitudinal data. The data in this section of the report are comparisons between teachers who report change based on their awareness of the *Standards* and teachers who report no such change.

The data in Table 1 indicate that teachers in the Changed group do indeed report higher frequencies for most of the teaching strategies we asked about, although for many strategies the percent of changed teachers reporting frequent use is still low in absolute terms.

For example, the frequency with which students in the Changed classrooms work on complex or open-ended "project" problems is higher at each grade level than the comparable frequency in Unchanged classrooms. However, fewer than 20% of Changed teachers report using this type of activity more than two times per month. More important, only 20 to 30 percent (depending on grade level) of teachers in the Changed group report that their students never work on project problems compared with 37 to 49 percent of the Unchanged group. Thus, although Changed teachers do not report use of project problems on a truly frequent basis, at all grade levels they are much more likely to use them, as compared with Unchanged teachers.

In a similar manner, with respect to the theme of mathematics as communication, although fewer than 25% of the Changed teachers report asking students to write about mathematical ideas two or more times a month, dramatic contrasts are also evident in the number of teachers in each group reporting that they never use this strategy. At all three grade levels, students in Changed classrooms are much more likely to be asked to do at least some writing about mathematics than students in the Unchanged classrooms.

The comparison of Changed with Unchanged teachers also allows us to identify areas in which even Changed teachers are not adapting to the recommendations of the *Standards*.

For example, the *Curriculum and Evaluation Standards* recommends that students make greater use of computer software to facilitate their development of problem-solving strategies. Although the slight differences in reported frequencies favor the Changed teachers in every case, the low numbers indicate that even teachers who are working to incorporate recommendations of the *Standards* apparently have had difficulty or are not willing to make changes in this area. Discussions in the focus groups identified a number of obstacles specific to the incorporation of technology in mathematics classrooms, including lack of access to hardware and to software applications, lack of training, and lack of time to experiment with existing applications in order to better integrate the use of such applications into their curriculum.

In summary, the evidence suggests that motivated teachers are making more frequent use of the teaching strategies recommended in each of the four areas highlighted by the *Standards*, as compared with the remaining teachers, who reported no efforts to change. These differences in implementation are evident with respect to the recommendations concerning reasoning and connections (which teachers as a whole already appear to be following to a significant degree), as well as those concerning problem-solving and communication (areas in which teachers as a whole report considerable room for improvement). The magnitude of these differences is sometimes substantial even in areas in which the recommendations of the *Standards* diverge from traditional practices, such as journal writing and work on open-ended problems. This analysis also highlights some areas in which progress has been slow even for motivated and aware mathematics teachers, suggesting the need for additional administrative support.

AIDS TO IMPLEMENTATION

Teachers report that more staff development is needed to assist them in making the transition to a more *Standards*-looking curriculum. Even focus group teachers who report that inservices are available often do not see much value in the type that they are receiving. They are requesting more content specific staff development. They overwhelmingly approve of time to see model teachers in action and having quality time discuss teaching ideas. Teachers see support from the principal and the guidance of lead teachers as very important. They want a principal who is well informed, who is able to discuss the *Standards* and who will work with mathematics teachers to find out what is required to implement them.

Comparison of Changed and Unchanged teachers in this area reinforces the impression that administrative support, and an active interest on the part of principals in teachers' efforts at implementation, are important sources of motivation for teachers who are working to change their instructional practices. Among elementary teachers, for example, teachers who were making changes in response to the *Standards* were much more likely to report that their schools or school divisions had:

- designated "lead" teachers
- provided special training for these lead teachers
- revised criteria for textbook selection
- offered one or more in-services on the *Standards*
- maintained a library of *Standards*-relevant materials.

The results of this comparison for middle and secondary school teachers were similar to those just reported for elementary teachers. Teachers who see themselves as changing in response to the recommendations of the *Standards* reported substantially higher levels of active administrative support, relative to teachers who do not see themselves as making such changes. This suggests that administrative changes may have a direct and beneficial effect on classroom practices in mathematics.

OBSTACLES TO IMPLEMENTATION

Time was a primary obstacle to implementation at all three grade levels. Elementary teachers described pressure to make changes in other curriculum areas, such as history and language arts, as well as in mathematics. Secondary teachers were more likely to cite lack of preparation time necessary to develop alternatives to the traditional, sequential mathematics curriculum. They also require time to coordinate with other teachers who worked with students during the prior year, or who would teach these same students the following year, to assure a coordinated sequence of instruction.

A second major obstacle, identified by teachers at all three grade levels, is the pressure to have students succeed on standardized tests. Teachers fear repercussions from administrators and parents in the event that changes in their class structure or content result in decreases in students' scores relative to national norms.

A third major obstacle is lack of resources, particularly technological aids (computers, calculators, and manipulatives). Teachers complained of having outdated equipment or severely limited access to the equipment that is available. Upper elementary and middle grade teachers do not have an accumulated supply of manipulatives and feel that these must be supplied.

Finally, an obstacle that emerged for teachers at the upper grades, but not for elementary teachers, was student ability levels and attitudes about mathematics. Apparently, teachers at middle and secondary schools perceive low levels of student ability as an obstacle to *Standards* implementation, as well as student attitudes about mathematics. These myths need to be addressed during inservice activities. Teachers in the focus groups commented on the improved learning and attitudes of low ability students. In the focus groups, secondary teachers of honors classes also report a reluctance on the part of these high-ability students to engage in open-ended, higher-order thinking activities due to the loss of grade security that such activities can cause.

GENERAL CONCLUSION AND SUMMARY

The implementation of the NCTM *Standards* appears to have the support of the majority of metropolitan teachers. Most are aware of the NCTM *Standards*, have access to a copy of the *Standards'* documents or related material in their schools and are in agreement with them. Significantly fewer teachers have actually made changes in their teaching consistent with the *Standards* or even feel prepared to explain them to colleagues. It is important to remember that "awareness" and "agreement with" the *Standards* is based here on teachers' self-reporting and not on objective classroom observation.

STRENGTHS

Overall the data suggests that there is an unevenness in the level of implementation. Some teachers have made changes, but many have not. However, even within those who have changed, change is not uniform, nor at a level indicative of full implementation. With a recognition of this unevenness, there are some areas where progress can be reported.

At the elementary and middle grades, teachers report use of cooperative groups, an increased use of manipulatives and computers, and there is some evidence of discussion and interaction in the classroom. The greatest areas of strength at the secondary level include mathematics as reasoning, cooperative group work, and the use of calculators.

WEAKNESSES

When looking at the frequency with which most any strategy is used, it is difficult to feel complacent about the data in any given area. Clearly, there remains a lot of work to be done before we can say teachers are actually implementing the *Standards*.

While problem-solving is reportedly done by all teachers, the evidence does not support the use of problem-solving as a global approach to mathematics or as a pervading theme. Nonstandard and project-type problems are infrequently used. The driving force in the classroom remains the textbook.

The area of assessment is perhaps least reflective of the *Standards* than any other area. There is little evidence of alternative forms of assessment, portfolios, or journals. Teachers made almost no distinctions between the use of assessment for diagnostic purposes and for grading. Traditional end-of-chapter and standardized tests remain the most common forms of assessment.

At the elementary level, calculators are used less frequently than desired and evidence would suggest that the curriculum at that level remains dominated by computational skills. While calculators are common at the upper grades and secondary school, there is an inadequate use of computer technology and of graphing calculators. It is not clear whether this is due to lack of availability or teacher reluctance or curricular support.

AIDS AND OBSTACLES

There are two factors that appear to be correlated with a movement toward a *Standards*-like classroom: (1) The support of the administration, especially at the principal level. (2) The initiative of individual teachers to take advantage of opportunities and to be self-starters. In the case of the latter, it is not clear what causes these personal characteristics.

Other factors that influence implementation of change are time (for planning, for inservice and professional growth opportunities), the pressures of standardized testing, quality inservice (or lack of same), and the availability of resources (especially in the area of technology). Teachers at the upper levels note the difficulties of working with students of low abilities as a significant obstacle.

IMPLICATIONS

In many ways, the study did not uncover any major surprises. On the whole, the findings are in agreement with those of the NCTM pilot study. Nor are the findings a surprise to the mathematics supervisors in the MERC school divisions or to the investigators. At the same time, the study does provide data to corroborate the viewpoint that much work

needs to be done and allows us to focus attention on specific areas that deserve attention.

The comments that follow are, of course, based on the independent interpretation of the investigators. However, we believe that they accurately reflect the differences between the findings of the study and the major directions recommended by the NCTM *Standards*.

CURRICULUM AND INSTRUCTIONAL PROCEDURES

Elementary Level

1. The entire area of computation at the elementary level should be looked at. The data suggest that most teachers spend the majority of their time on pencil-and-paper computational skills while spending little time on mental computation and computational estimation. It is fairly clear that the current emphasis is a function of textbooks, standardized testing, and long-standing traditions, each of which have consistently stressed pencil algorithms as the backbone of the elementary mathematics curriculum. The *Standards* calls for a de-emphasis on these outdated skills with an increased emphasis on more flexible and more frequently used mental methods. Teachers will need inservice and support from curriculum materials to make this change.

2. While teachers report addressing the area of problem-solving, it is not clear that the full curriculum is being approached in a problem-solving manner. The first theme standard is mathematics *as* problem-solving. To implement this theme requires teachers to have a more complete understanding of the full intent and philosophy of the *Standards*. Teachers still seem to see mathematics as a rule-driven curriculum rather than one in which students are involved in the discovery and invention of mathematical ideas through problem-solving methods.

3. The data suggest that calculators are only used infrequently in the elementary school. Based on the focus group interviews and on informal observations, it is

most likely that very few teachers require students to have calculators or have them readily available at all times. The *Standards* calls for calculators to be available at all times and to be used in all areas of mathematics including assessment. There are a number of ways to get inexpensive calculators into the hands of every elementary child, including making them required material for school. The daily or regular use of calculators must begin with availability and be followed with ideas for using them.

4. The areas of geometry, probability and statistics should be given significantly more visibility in the required curriculum. The evidence suggests that geometry receives only minimal attention and that probability and statistics are rarely taught. Once again, textbooks, testing programs, and lack of a tradition of teaching in these areas are the targets that need to be addressed.

5. While primary grade teachers are comfortable at least with the idea of using manipulative materials, upper-grade teachers are facing unfamiliar challenges. They lack experience with managing manipulatives in the classroom. They do not have experiences with making materials nor do they have adequate commercial supplies to support a manipulative approach. They also need help with ways to use manipulatives with older students.

Middle School Level

1. As at the elementary level, computation and number sense appear to receive the most attention in the middle-grades curriculum. Although it may appear from the data that teachers include number sense in their instruction, it is not clear that the term *number sense* is clearly understood in the same sense as is meant by the *Standards*. At this level, mental computation and computational estimation are clearly a component of number sense as is a connection of number concepts with real word referents. In these areas, teachers are not reporting strong instructional emphasis. More attention should be given to a broad view of number sense while

simultaneously deemphasizing pencil-and-paper computation. Textbooks, testing, and teacher knowledge of the curriculum must all be addressed in order to promote change.

2. Middle school teachers seem to be considerably more textbook bound than their counterparts at the elementary level. They need more assistance in how to teach mathematics through open-ended explorations, projects, and group work. A problem-solving approach and the use of manipulatives in middle grades is rarely seen. A more exploratory, discussion-oriented approach is recommended by the *Standards*.

3. The middle school teachers tend to use calculators more than at the elementary level but not on a daily or even regular basis by any means. The use of computers is actually weaker than at the elementary level. In fact, due to some of the more recently available computer software, the teacher of the middle grades has more reason to use computers now than ever and the calculator should be an ever-present tool at the disposal of the middle-grades student. In fact, in the 1992 NCTM Yearbook on calculators in mathematics, a strong case is made for the use of graphing calculators at the middle grade level.

4. The curricular areas of patterns, measurement, statistics and probability are all in need of increased emphasis in the middle grades if the *Standards* are to be addressed.

Secondary Level

1. The notion of a core-curriculum at the secondary level is one of the main themes of the NCTM Standards. The core-curriculum concept envisions all students having access to significant mathematics with no one being denied access due to lack of computational skills. The differentiation between college-intending and noncollege-intending students is determined by the depth of study, not what is

studied. Thus, all students should have access to algebra, geometry, probability and statistics, and discrete math topics.

The current study was not designed to determine specifically if a core curriculum was in place. However, there was little evidence that suggested the existence of a core curriculum. For example, there remains a lot of traditional instruction in skill areas for lower-level students. No discussion of addressing a variety of mathematical topics for all students was noted. To move toward a core curriculum is a major step for any school division and requires significant changes in the total curricular offerings for the four years of secondary schools. While the study itself did not uncover such changes, it is noted that at least two of the MERC school divisions have begun implementation of some form of a core-curriculum concept.

2. The secondary teachers in the study report using calculators fairly regularly. However, it is clear from the focus groups that graphing calculators are far from a standard tool. It is more likely that only one or two teachers are using graphing calculators or have taken the time to learn how to use them. For under $70 each, these calculators are essentially small computers that can be programmed, used for investigating graphs, working with statistics, computing matrices, and much more. Students in college-bound programs should be encouraged to purchase their own graphing calculators, schools should have them available for use, and most importantly, nearly every secondary school course should take advantage of them. This will require some training or at the very least some support in terms of curricular materials.

3. Computer usage is also weak and spotty. In the opinion of the teachers, much of the problem is hardware and software compatibility. Simply purchasing computers and/or software is not sufficient Teachers must be afforded time and support to learn about the software and computers must be installed in usable configurations and be compatible with the desired software.

4. Secondary teachers could improve their problem-solving approach to instruction including the use of cooperative learning groups, project problems, and more student writing.

ASSESSMENT

Of the areas investigated, assessment strategies and procedures was the area where teachers have made the least amount of change in the direction of the *Standards*. This is true at all grade levels and little is gained by separating the three levels in this discussion.

The predominant mode of assessment is the chapter test and related quizzes. While teachers report that they assess concepts as well as procedures, an examination of the typical chapter test will indicate that the conceptual understanding required is minimal. Most teachers are concerned about standardized testing, reporting numeric grades backed up by test averages and the performance of routine procedures. While these are not bad objectives, they represent an incomplete approach to assessment.

In their reporting, teachers made almost no distinction between the use of any assessment procedure for grading purposes versus instructional feedback or diagnosis. One interpretation that may be made is that they really do not make this distinction at all. It is unlikely that they do as much assessment for diagnosis as for grading as is suggested by the data.

The *Standards* calls for assessment to be much less distinct from instruction than has traditionally been the case. By broadening an assessment plan to include observations, checklists, portfolios of work, group projects, and performance tasks, the things that students do in class as part of their learning experiences can also be included in an assessment plan. Furthermore, the *Standards* calls for alignment of all assessment, not just with objectives of the course but also with the methods of instruction. If calculators

and/or manipulative materials are used in the instructional program perhaps they should also be used in the assessments.

With the possible exception of some observations and group work being used at the elementary level and calculators permitted in most secondary class testing situations, it is safe to say that teachers are still using the same assessment procedures that they always have.

The researchers' experiences with teachers taking courses suggest that learning to implement and use effectively a broader, performance-based plan of assessment that is integral to instruction, is a very difficult task. It requires considerable instruction in assessment strategies and having the opportunity to try them out in the classroom. Teachers must begin small and find one or two new ideas that suit their personal style and agenda. From this beginning they can gain confidence and add additional strategies later.

Teachers who do adopt a variety of alternative assessment procedures tend to be very positive about the results – except for the hard work that is almost always involved. If school divisions want to help teachers look more broadly at student achievement and report more accurately to parents what students are able to do (instead of what they cannot do), schools must do more than provide one-shot inservice. They must develop a plan that will guide and support teachers, offer them choices, and show them the benefits of the additional work involved. This is easily one of the most difficult areas of the *Standards* to implement.

AIDS TO IMPLEMENTATION

The data, especially the focus group interviews, provide useful information concerning the types of things that can influence (or hinder) change and general implementation of the *Standards*. Some of these things must involve division change or division implementation. We might call these structural changes - changes that are beyond the control of the

individual teacher or principal. Other factors influencing change are more local. These factors are under the control of the building principal or department chair, or can be dealt with through inservice and other avenues of professional growth. Local factors are still influenced at the division level. For example, providing quality, focused inservice is listed here as a nonstructural aid. However, to follow up on that inservice or to implement the suggestions remain in the control of the teachers and principal. Implementation of a core curriculum at the secondary level is clearly structural, requiring division implementation.

Structural Initiatives

1. The development of a clear policy relative to the NCTM *Standards*, coupled with information and appropriate modifications in the curriculum, would help teachers and principals have a sense of direction that is sometimes lacking. Teachers, even those who are well aware of the *Standards*, are not clear about what they themselves should be doing in the classroom. Conflicting messages concerning objective lists, SOL's, ITBS and other mandates are not always in sync with the message of the *Standards.* It is not reasonable for teachers to be expected to make change with only a simple admonition that we support the *Standards*. Information about the *Standards* and how the division views implementation is important for all concerned.

2. Testing policies should be examined to be in keeping with the *Standards* It is, of course, important to be aware of test scores as a measure of how well a school or division is doing. However, it is now very important to take a careful look at the items that are included in those tests. The current version of the ITBS is heavily weighted toward procedural or algorithmic knowledge with very little emphasis given to concepts and problem-solving skills. Textbooks also have chapter-end tests that tend to focus on the lowest level skills of the chapter.

3. Examine policies relative to textbook adoption and be certain that they are in keeping with the spirit of the *Standards*. When textbooks are not in keeping with pronounced directions, either because they are out of date or because they were selected with out-dated criteria, they are of no real help to teachers.

Local Initiatives

1. Promote and support the lead teacher concept. Many teachers talked of the value of having a lead teacher in the school - someone they could count on to have current information or a good idea to solve a problem. Lead teachers are present in many divisions but require the constant support of principals since no moneys are available for mathematics specialists. At the secondary level, the department chairs should be encouraged to be instructional leaders in the same way as the lead teacher is at the elementary and middle school level.

2. Make opportunities for teachers to observe one another within the buildings and encourage teachers to share ideas and problems about teaching mathematics. Teachers truly value ideas that come from their colleagues.

3. Provide quality inservice that is focused on specific classroom issues in the teaching of mathematics. Teachers react negatively to inservice that is not specifically useful to them or is so general in nature that significant implementation problems make using the information nearly impossible. Relevance of inservice is very important. If the inservice is good, support should be available to follow up on it. That support should come in the form of sharing, materials, encouragement, and time to work on implementation.

4. Principals need to be knowledgeable about the NCTM *Standards*. While a relatively high number report awareness of the *Standards*, there is also evidence that a principal who is truly involved in making the *Standards* a reality in the school is somewhat of an anomaly. As teachers spend extra time and effort at

implementation of new ideas and request support for materials, manuals, software, calculators, and help from others, these efforts and requests must not fall on deaf ears. Teachers cannot implement the *Standards* without support.

5. Be very sure that teachers are aware of opportunities for professional growth. Professional journals and books from NCTM could be made available. Opportunities to attend conferences at the local, state, regional and even national level should at the very least be well publicized and discussed. When possible, funds, such as Eisenhower money, should be made available to get teachers to these meetings. Teachers should be encouraged to attend special training courses, take workshops and even university courses. When teachers do make these efforts, their efforts should be rewarded - at the very least with recognition and praise if not with more tangible means of support for work in the classroom.

6. Examine issues and concerns around technology. Simple calculators should be available to every child at all times. Teachers should not have to go to a central place to get the "grade-level" set. Where reasonable, school policy could permit students be required to bring a simple calculator to school. For more expensive technologies, similar policies should be made in cooperation with the teachers. Care should be taken to see that computers that are available are in good repair, that there is reasonable software to use on the computers. All teachers at all levels need help in how to use technologies in their courses. It is not reasonable to expect them to use a new tool without assistance.

CONCLUSION

The NCTM *Standards* document is now four years old and the *Professional Teaching Standards* are two years old. These recommendations, while universally accepted across the nation, are not likely to be easily implemented in their entirety. NCTM itself recognizes that true implementation is a long-term endeavor that will extend into the next century. The findings of this survey are generally consistent with these expectations. There is

some movement in a positive direction as more and more teachers are at least aware of an agenda for change. Actual significant change on any global basis, however, is very difficult to find. Teachers are in serious need of support as well as education concerning what the *Standards* are actually saying.

Glenda Lappan, Chair of the Commission on Teaching Standards for School Mathematics, writes:

> *The kinds of change called for by the vision in the standards documents are so fundamental and pervasive that they seep into every aspect of our society. The current curriculum, expectations, and teaching practices are failing with so many of our students in mathematics that we have a responsibility to rethink what we are about. To accomplish change on a large scale, all the stakeholders - students, teachers, parents, school administrators, business, industry, professional mathematicians, politicians, and others - need to understand the issues and the direction of reform and give their support to the effort.*
> Arithmetic Teacher, May, 1993, p. 526.

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